The effect of sound quality on attention and load in language tasks

Kilian Seeber, Dongpeng Pan

Faculty of Translation and Interpreting, University of Geneva, Switzerland

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Abstract

In this paper, we report the first part of the results of a study on the effect of sound quality on attention and load during different language processing tasks. Forty-two professional conference interpreters completed three tasks (comprehension, production, and simultaneous interpreting of sentences) in high-quality and low-quality audio conditions. The first sentence (of the type, "The man/woman is at the *location*") was accompanied by a visual array with three images: the smallest object (Target X), the bigger object (Foil) and the biggest object (Target Y). Gaze patterns and pupil diameter were measured during the second sentence (of the type, "The *Target X* is next to the *Target Y*") in a blank-screen paradigm. There were 12 visual arrays for each task. We found that participants shifted their attention to the mentioned target earlier in adverse sound conditions in both the comprehension and the interpreting task, and cognitive load is higher during interpreting than it is during comprehension.

Keywords: visual world paradigm, attentional shift, cognitive load, language comprehension, simultaneous interpreting.

Introduction

This study aims to investigate the effect of sound quality on attention and cognitive load in the comprehension, production, and simultaneous interpreting of sentences by analysing participants' eye movements towards sequentially occurring targets. To that end, we designed a blank screen visual-world eye-tracking experiment to measure attentional shift patterns. Pupil diameter was used as an indicator of real-time cognitive load. In this paper, we report and briefly discuss results for sentence comprehension and simultaneous interpreting.

Methodology

Forty-two Geneva-based professional conference interpreters participated in the study. All interpreters were L1 speakers of either French, German, Spanish, Italian or Russian and had English as an L2 language.

Thirty-six experimental visual arrays were created; 12 for each experimental task, i.e., comprehension, production, and simultaneous interpretation. Each array contained three images representing objects of different sizes: the smallest object (Target X), the bigger object (Foil) and the biggest object (Target Y), e.g., a shrimp, a jellyfish, and a whale.

For the comprehension and the interpreting task, participants heard an introductory sentence and a critical sentence. The introductory sentence provided context (e.g., "The man is at the aquarium"). The critical sentence described the location of the two targets in relation to each other (e.g., "the shrimp is next to the whale). In the comprehension task, participants were asked to look at the screen and listen to the sentences. In the interpreting task, participants were asked to look at the screen and simultaneously interpret all sentences into their respective L1.

The experiment was based on the blank screen paradigm (Altmann 2004), where images of objects are not visible during the critical part of the sentence. Consequently, participants only saw the visual stimuli during the first, introductory sentence, while during the critical sentence the screen was blank. The audio stimuli for half of the trials had a frequency range of 125Hz to 15KHz (i.e., high quality: HQ), the other half of 300Hz to 3400Hz (i.e., low quality: LQ). Tasks were blocked and randomly rotated.

To illustrate participants' shifts of visual attention among objects over time, bootstrapping was used. Resampled datasets were created, and a one-sample t-test on fixation proportions was conducted after each resample, without assumptions about the population distribution (Stone et al. 2021). A divergence point represents the first time point followed by at least ten consecutive time points with significant t-values. Then, we used a non-parametric bootstrap to create new datasets by resampling participant, timepoint, and object type (Target X vs Target Y, Target X vs Foil, and Target Y vs Foil). The bootstrap comprised 2000 iterations.

Pupil diameter was used as an indicator of real-time variations in cognitive load during sentence comprehension (Just and Carpenter 1993) and simultaneous interpreting (Seeber 2013).

Results

Bootstrapped means and CIs for HQ and LQ of the comprehension task are plotted in Figure 1. In the HQ condition, during the PePOI "the X", participants tend to look at Target X, the mentioned object, more than at Target Y, the significant divergence beginning 933.78 [820, 990] ms after sentence onset. Similarly, during the POI "the Y", participants look at Target Y, the mentioned object, more than Target X, albeit with a very late divergence onset at 3131.516 [2644.57, 3554.5]. In the LQ condition, during the POI "the X" participants' preference of looking at Target X, the mentioned object, over Target Y, is no longer significant and merely a trend. During the POI "the Y", participants look at Target Y, the mentioned object, more than at Target X, with a significant divergence onset at 2555.244 [2494.57, 2574.57]. Participants' shift from Target X to Target Y occurs about 300ms earlier during the LQ condition.

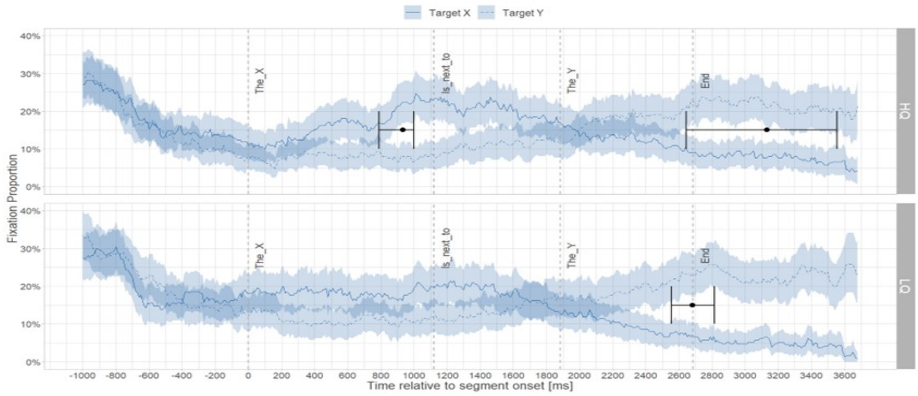

Figure 1 Divergence points and 95% confidence intervals superimposed on the fixation curves, depicting fixation to Target X and target Y of the comprehension task.

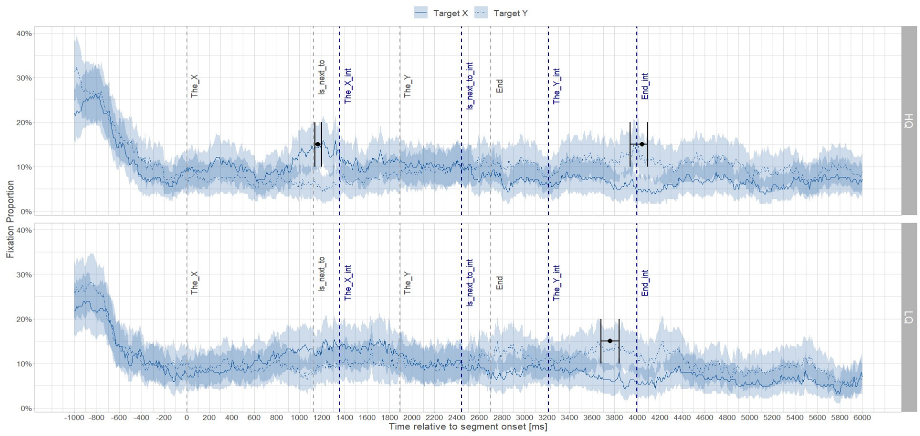

Figure 2 Divergence points and 95% confidence intervals superimposed on the fixation curves, depicting fixation to Target X and target Y of the interpreting task.

Bootstrapped means and CIs for HQ and LQ of the interpreting task are plotted in Figure 2. In the HQ condition, during the POI "the X", participants tend to look at Target X, the mentioned object, more than at Target Y, although the first significant divergence occurs at 1165.071[1136.5, 1196.5] ms from sentence onset, and thus during the POI "is next to". During the POI "the Y" participants tend to look at Target Y, the mentioned target, more than Target X, although the significant divergence onset does not start before 4045.1

[3940.1, 4090.1], the thus after the POI "the Y*interpretation*". In the LQ condition, the only significant divergence between looks at Target X and Target Y starts at 3760.1[3680.1, 3840.1], during the POI "the Y*interpretation*", with participants looking at Target Y more than at Target X. Like in the comprehension task, visual attention to Target Y shifted earlier in the LQ condition.

The analysis of participants' pupil size across tasks and sound quality conditions shows significantly larger pupil diameter during POI "Target Y" as compared to "Target Y" in both tasks. During comprehension, LQ sound did not significantly affect pupil diameter. During interpreting, pupil size was significantly larger than during comprehension, and LQ sound engendered significantly larger pupil diameter than HQ sound.

Conclusion

Sound quality modulates the shift of visual attention (measured as proportion of fixations) to mentioned objects during comprehension and simultaneous interpreting, suggesting a quantitative and a temporal effect. On the one hand, low sound seems to decrease the likelihood of shifting visual attention to the first object mentioned. On the other hand, it appears to increase the speed with which visual attention is allocated to the second object mentioned.

Cognitive load (measured as pupil diameter) is significantly higher during interpreting than it is during comprehension. Also, while the low-quality sound used in this experiment did not modulate load during comprehension, it generated significantly higher load during simultaneous interpreting. Regardless of the task, load significantly increases towards the end of the sentence.

References

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